# A SURVEY OF UNITED STATES AND TOTAL WORLD PRODUCTION, PROVED RESERVES AND REMAINING RECOVERABLE RESOURCES OF FOSSIL FUELS AND URANIUM AS OF DECEMBER 31, 1976

by

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In this report, current estimates are presented for U.S. and world nonrenewable energy sources. The data are presented in summary form due to space limitations. The full paper, available on request from the authors, presents full details of the resource estimates. U.S. fossil fuel resources are reported as of December, 1977. However, for the summary world resource tables, 1976 U.S. data were used to be consistent with the latest estimates available for other world areas.

## U.S. Nonrenewable Energy Sources

The following tables present estimates for the remaining recoverable U.S. fossil-fuel resources. Table 1 summarizes the estimates for natural gas made over the past several years by recognized agencies: the American Gas Association (A.G.A.), the Potential Gas Agency, the U.S. Geological Survey (U.S.G.S.), the National Academy of Sciences (NAS), IGT, and some oil and gas producing companies. Table 2 summarizes recent crude oil estimates made by the American Petroleum Institute (A.P.I.), U.S.G.S., NAS, and others. In view of the considerable disagreement among the published data, a high degree of accuracy cannot be claimed despite the unquestionable expertise of the agencies involved.

Remaining recoverable resources as of year-end 1977 are given in Table 3 for the various fossil fuels based on the publications of the above agencies, and the U.S. Bureau of Mines. As in Tables 1 and 2, resources are reported both for the portions qualifying as proved reserves and for the estimated total remaining economically recoverable resources. In both cases recovery is to be economical with current technology. Because of uncertainties, ranges of total remaining recoverable resources have been used for most of the fossil fuels.

## U.S. Life Expectancy

Table 4 shows the life expectancy of U.S. fossil fuels in the aggregate (including shale oil and bitumens), with consumption based solely on domestic production and increasing at various fixed annual rates of growth - 2%, 3%, and 4%. It is also based on reducing the resources to a 10-year forward reserve at the annual production rate ultimately reached. For example, if the demand for fossil fuels were to grow at 3%/year, the listed total remaining recoverable fossil fuels would last another 85 years under the conditions stipulated. If restricted to the reserves currently proved, the life expectancy would drop to 32 years. However, if the total remaining recoverable resources could be augmented to twice the present estimated level

Table 1. Estimates of Remaining Recoverable U.S. Natural Gas Resources at Year-End

| Year End | Source | Potential Supply: Old Fields | Potential Supply: New Fields | Proved Reserves A.G.A. | Total |
|---|---|---|---|---|---|
| | | trillion cubic feet | | | |
| 1977 | American Gas Association | -- | -- | 209 | -- |
| 1976 | Potential Gas Committee | 215 | 733 (708-758) | 216 | 1164 |
| | Exxon | 111 (56-321) | 287 (127-657) | | 635 (420-1215) |
| | U.S. Geological Survey (Miller, Thomsen, et al) | 201.6 | 484 (322-655) | | 923 (761-1094) |
| 1974 | National Academy of Sciences | 118.6 (calcd) | 530 | 237 | 886 |
| | Moody | 65 | 485 | | 787 |
| | Average, some major oil cos. (Garrett) | 100 | 500 | | 837 |
| 1973 | Mobil Oil Corp. (Moody and Geiger) | 65 | 443 | 250 | 758 |
| | U.S. Geological Survey (McKelvey) | 130-250 | 1000-2000 | 266 | 1396-2516 |
| 1972 | Potential Gas Committee | 266 | 880 | | 1412 |
| | IGT (Linden) | 634 (old and new fields) | | | 900 |
| | U.S. Geological Survey | 130 (calcd) | 361 | | 770 |
| 1971 | (Hubbert) | | | 279 | |
| | IGT (Linden) | 575-704 (old and new fields) | | | 854-983 |

Table 2. Estimates of Remaining Recoverable U.S. Crude Oil Resources at Year-End

| Year End | Source | Potential Supply: Old Fields | Potential Supply: New Fields | Proved Reserves A.P.I. | Total |
|---|---|---|---|---|---|
| | | Billion bbl | | | |
| 1977 | American Petroleum Institute | -- | -- | 33.7 | -- |
| 1976 | American Petroleum Institute | -- | -- | 35.2 | -- |
| | Exxon, rev. | 59 | 63 | 41 | 163 |
| | Exxon | 57 (36-90) | 55 (20-129) | 34.25 | 146 (90-253) |
| 1974 | U.S. Geological Survey (Miller, Thomsen, et al.) | 23.1 | 50-127 | 38.9 | 112-189 |
| | National Academy of Sciences, Incl. natural gas liquids | 22.7 (calcd) | 105-120 | 45.3 | 173-188 |
| 1973 | Mobil Oil Corp. (Moody and Geiger) | 11 (calc) | 88 | 40.4 | 139 |
| 1972 | U.S. Geological Survey, Incl. natural gas liquids (McKelvey) | 24-45 | 200-400 | 48.3 | 272-493 |
| 1971 | U.S. Geological Survey (Hubbert) | 18 (calcd) | 55 | 43.0 | 116 |
| 1970 | U.S. Geological Survey, Incl. natural gas liquids (Theobald, et al.) | 450 (old and new fields) | | 52.1 | 502 |
| | National Petroleum Council | -- | -- | -- | 339 |

in some way (i.e., imports), they would last 108 years. Some recent forecasts suggest that the growth rate of consumption might decrease to 2.5% or less. Hence, there should be adequate lead time to develop synthetic fuels from coal, oil shale, and bitumens, and allow use of the quantities of these materials suggested in Table 3.

Table 3. U.S. Fossil Fuel Resources as of December 31, 1977

| | Proved and Currently Recoverable | | Estimated Remaining Recoverable | |
|---|---|---|---|---|
| Dry Natural Gas | | | | |
| Trillion CF | 209 | | 760-1170 | |
| Quintillion ($10^{18}$) Btu | | 0.21 | | 0.78-1.19 |
| Natural Gas Liquids | | | | |
| Billion bbl | 6.0 | | 21-33 | |
| Quintillion Btu | | 0.02 | | 0.09-0.13 |
| Crude Oil | | | | |
| Billion bbl | 29.5 | | 144-371 | |
| Quintillion Btu | | 0.17 | | 0.84-2.15 |
| Coal | | | | |
| Billion short tons | 214 | | 1036-1788 | |
| Quintillion Btu | | 4.72 | | 20.71-35.75 |
| Shale Oil | | | | |
| Billion bbl | 74 | | 1026 | |
| Quintillion Btu | | 0.43 | | 5.95 |
| Bitumens | | | | |
| Billion bbl | 2.5 | | 15 | |
| Quintillion Btu | | 0.01 | | 0.09 |
| Total, Quintillion Btu | | 5.56 | | 28.46-45.26 |

4. Life of U.S. Fossil Fuel Resources
At Various Demand Growth Rates
(Based on 1977 Year-End Estimates)

| Annual Growth Rate, % | Date When Remaining Reserve/Consumption Ratio Drops to 10 Years | | |
|---|---|---|---|
| | A | B | C |
| 4 | 2004 | 2046 | 2063 |
| 3 | 2009 | 2062 | 2085 |
| 2 | 2015 | 2090 | 2123 |

A Proved reserves (5.56 X $10^{18}$ Btu)
B Total remaining recoverable resources (36.9 X $10^{18}$ Btu).
C Effective doubling of B resources.

## World Nonrenewable Energy Sources

Proved recoverable and total remaining recoverable resource data for the world are shown in Table 5 in conventional units and in the common energy units Btu and metric tons of coal equivalent (tce).

World totals for proved recoverable and total remaining recoverable resource data for the world on a regional basis are shown in Table 2 in conventional units. The total remaining recoverable resources include proved reserves. Natural gas and crude oil proved reserves for the various regions are based primarily on the annual estimates for the component countries published by World Oil and by Oil & Gas Journal. Natural gas and crude oil remaining recoverable resources over and above proved resources are based on published estimates by a number of authorities.

Table 5. Nonrenewable World Energy Total Resources (December 31, 1976)

| | Proved and Currently Recoverable | Estimated Total Remaining Recoverable |
|---|---|---|
| Natural Gas | | |
| Trillion ($10^{12}$) CF | 2118-2450 | 9090-9490 |
| Billion ($10^9$) tce | 79-91 | 337-352 |
| Quintillion ($10^{18}$) Btu | 2.18-2.52 | 9.36-9.78 |
| Natural Gas Liquids | | |
| Billion bbl | 56-65 (Est.) | 241-251 (Est.) |
| Billion tce | 8.3-9.6 | 36-37 |
| Quintillion Btu | 0.23-0.27 | 0.99-1.03 |
| Crude Oil | | |
| Billion bbl | 538-606 | 1500-1840 |
| Billion tce | 112-127 | 313-384 |
| Quintillion Btu | 3.12-3.52 | 8.70-10.67 |
| Syncrude From Oil Shale and Bitumen | | |
| Billion bbl | 270 | 2415 (17,500)* |
| Billion tce | 56 | 504 (3654)* |
| Quintillion Btu | 1.57 | 14.01 (101.5)* |
| Coal | | |
| Billion short tons | 662 | 5367-6119 |
| Billion tce | 492 | 3864-4406 |
| Quintillion Btu | 13.67 | 107.34-122.38 |
| Total Fossil Fuel Energy | | |
| Trillion tce | 0.748-0.776 | 5.054-5.683 |
| Quintillion Btu | 20.8-21.5 | 140.4-157.9 |
| Uranium Oxide at <$30/lb | | |
| Thousand short tons | 2443 | 6624 |
| Burner Reactors | | |
| Trillion tce | 0.035 | 0.093 |
| Quintillion Btu | 0.977 | 2.570 |
| Breeder Reactors | | |
| Trillion tce | 2.64 | 6.94 |
| Quintillion Btu | 73.28 | 192.7 |
| Total Fossil Fissile Energy | | |
| Burner Reactor | | |
| Trillion tce | 0.783-0.811 | 5.147-5.776 |
| Quintillion Btu | 21.7-22.5 | 143.0-160.4 |
| Breeder Reactors | | |
| Trillion tce | 3.386-3.414 | 11.992-12.621 |
| Quintillion Btu | 94.0-94.8 | 333.1-350.6 |

* See footnote (††)in Table 6.

Note: In the conversion from conventional to energy units the assumed energy equivalents are:

- 1031 Btu/CF of natural gas
- $5.8 \times 10^6$ Btu/bbl of crude oil or syncrude
- $4.1 \times 10^6$ Btu/bbl of natural gas liquids
- $20 \times 10^6$ Btu/short ton of coal (mixture of types), except for U.S. proved reserves where $22 \times 10^6$ Btu/short ton was used
- $400 \times 10^9$ Btu/short ton of $U_3O_8$ in burner reactors
- $30 \times 10^{12}$ Btu/short ton of $U_3O_8$ in breeder reactors
- No plutonium recycle is assumed for burner reactors.
- 1 tce = $27.778 \times 10^6$ Btu.

Table 6. Nonrenewable World Energy Resources By Region
(December 31, 1976)

| | Proved and Currently Recoverable | Estimated Total Remaining Recoverable |
|---|---|---|
| | Billion ($10^9$) Units | |
| United States | | |
| Natural Gas, 1000 CF | 216 | 790-1160 |
| Natural Gas Liquids, bbl | 6.4 | 21-31 |
| Crude Oil, bbl | 30.9 | 148-374 |
| Shale Oil, bbl | 74 | 1026 (2000) †† |
| Bitumens, bbl | 2.5 | 15 |
| Coal, short tons | 215 | 1036-1788 |
| Uranium Oxide* | | |
| short tons at <$15/lb | 410 | 1675 |
| short tons at <$30/lb | 680 | 3370 |
| Western Hemisphere (Incl. U.S.A.) | | |
| Natural Gas, 1000 CF | 352-382 | 2546-2946 |
| Natural Gas Liquids, bbl | 9.3-10.1 | 67-78 |
| Crude Oil, bbl | 66-71 | 320-420 |
| Shale Oil, bbl | 130 | 1500 (5000) |
| Bitumens, bbl | 80 | 500 |
| Coal, short tons | 224 | 1114-1866 |
| Uranium Oxide* | | |
| short tons at <$15/lb | 628 | 2345 |
| short tons at <$30/lb | 955 | 4331 |
| Europe (Excl. U.S.S.R.) | | |
| Natural Gas, 1000 CF | 152-173 | 484 |
| Natural Gas Liquids, bbl | 4.0-4.6 | 13 |
| Crude Oil, bbl | 19-26 | 39-79 |
| Shale Oil, bbl | 15 † | 150 (1400) |
| Bitumens, bbl | N.A. | N.A. |
| Coal, short tons | 141 | 356 |
| Uranium Oxide* | | |
| short tons at <$15/lb | 76 | 129 |
| short tons at <$30/lb | 621 | 914 |

Table 6. Nonrenewable World Energy Resources By Region (cont.)
(December 31, 1976)

| | Proved and Currently Recoverable | Estimated Total Remaining Recoverable |
|---|---|---|
| | Billion ($10^9$) Units | |
| Asia - Pacific (Incl. European U.S.S.R.) | | |
| Natural Gas, 1000 CF | 1415-1672 | 5064 |
| Natural Gas Liquids, bbl | 37.5-44.3 | 134 |
| Crude Oil, bbl | 402-445 | 1005-1175 |
| Shale Oil, bbl | 35 | 115 (6500) |
| Bitumens, bbl | N.A. | N.A. |
| Coal, short tons | 280 | 3865 |
| Uranium Oxide* | | |
| short tons at <$15/lb | 322 | 427 |
| short tons at <$30/lb | 367 | 501 |
| Africa | | |
| Natural Gas, 1000 CF | 199-223 | 996 |
| Natural Gas Liquids, bbl | 5.3-5.9 | 26 |
| Crude Oil, bbl | 50-63 | 136-166 |
| Shale Oil, bbl | 10 | 100 (4100) |
| Bitumens, bbl | N.A. | N.A. |
| Coal, short tons | 17 | 32 |
| Uranium Oxide* | | |
| short tons at <$15/lb | 370 | 423 |
| short tons at <$30/lb | 500 | 677 |

* Thousands of units
† Not available
‡ Values in parenthesis include estimates of undiscovered or unappraised resources in the 25-100 gal/ton yield range according to Duncan and Swanson, "Organic-Rich Shale of the United States and World Land Areas," U.S. Geol. Surv. Circ. 523.

Coal resource data are those of the World Energy Conference 1974 Survey of Energy Resources, except for the United States, where U.S. Bureau of Mines data are used. Allowance has been made for recent production; a mining loss of 50% is assumed.

Uranium oxide ($U_3O_8$) resources are expressed in terms of the $U_3O_8$ content of ores and forward cost rather than the actual market price, which has been rising rapidly. No allowance is made in forward cost for amortization of capital, financing cost, or profit. The U.S. data, from ERDA, are as of year-end 1976; all other data, reported jointly by the European Nuclear Energy Agency and the International Atomic Energy Agency, are as of year-end 1974. The communist countries' resources are excluded due to the lack of suitable data.

Both 1976 production and cumulated production of natural gas, petroleum, coal, and uranium oxide are shown in Table 7. Cumulated production data for the United States come from the U.S.G.S. and ERDA and have been updated by the use of recent production data.

Estimates of life expectancy of world fossil resources based on the quantities given in Table 1 and on the current production rate increasing at selected fixed annual growth rates are shown in Table 8. Fortunately, the life expectancy of remaining recoverable world fossil fuel resources, as now estimated, is of the order of 100 years at a reasonable growth rate of 2% to 3%/yr.

Table 7. Nonrenewable Energy Sources Current and Cumulated Production

| | Natural Gas Trillion CF | Petroleum,* Billion bbl | Coal, Billion short tons | $U_3O_8$, 1000 short tons |
|---|---|---|---|---|
| World | | | | |
| 1976 | 54-55 | 21.1 | 4.2 | [26]† |
| Cumulated | 888-913 | 359-366 | 154 | 572 |
| United States | | | | |
| 1976 | 19.8 | 2.97 | 0.671 | 12.7 |
| Cumulated | 519 | 112.0 | 44.2 | 295 |

* Gross minus reinjection.
† Estimate.

Table 8. Life of World Fossil Fuel Resources At Various Fixed Demand Growth Rates (Based on 1976 Year-End Estimates)

| Annual Growth Rate, % | Year When Remaining Reserve/Consumption Ratio Drops to 10 Years | | |
|---|---|---|---|
| | A | B | C |
| 4 | 2005 | 2050 | 2067 |
| 3 | 2010 | 2067 | 2090 |
| 2 | 2017 | 2097 | 2130 |
| 1 | 2029 | 2164 | 2226 |

A: Proved reserves: 0.748 to 0.776 x $10^{12}$ tce; mean = 0.762 x $10^{12}$ tce.

B: Total remaining recoverable resources: 5.054 to 5.683 x $10^{12}$ tce; mean = 5.369 x $10^{12}$ tce.

C: Doubling of estimated B resources.

Note: Calculations are based on growth at fixed selected annual increases of 1% to 4% from the 1976 world annual production of 8.695 x $10^9$ tce, as estimated by the U.N.

## Peat Resources

Although peat has been used as a fuel for centuries, it is not included in conventional resource estimates because of the general lack of information on the extent of the reserves and the potential contribution to world energy supply. Some incomplete data on world peat resources is shown in Table 9. Based on available data peat lands occupy an estimated 408.8 million acres of land in the world. These data show that the Soviet Union has 228 million acres, about 56% of the total world peat resource area-wise. The Soviet Union annually produces some 205 million tons, about 95% of the world's annual production. Total acreage of peat land in the U.S. is 52.6 million acres. Finland ranks third in total extent of peat lands and Canada fourth. It is to be noted that the resources listed for Canada exclude the Arctic regions. If these were included it is likely that the Canadian resources would be much higher than shown, and Canada would probably rank second to Russia in total peat resources.

Currently, only Russia, Ireland and Finland use large quantities of peat for fuel, mostly for generation of electric power. Research underway to convert peat to gaseous and liquid fuels could result in an accelerated development of this somewhat neglected energy source.

The basic problem with estimation of peat resources is that while the areal extent of peat deposits is fairly well known, data on the thickness of such deposits is sparse. Therefore, estimates in terms of energy content are difficult to make.

Table 9. World Peat Resources and Annual Production(1)

| Country | Acres (millions) | Annual Production (%) | Annual Production (million tons) |
|---|---|---|---|
| U.S.S.R. | 228.0 | 95.70 | 205.0 |
| U.S.A. | 52.6 | 0.30 | 0.6 |
| Finland | 35.6 | 0.36 | 0.7 |
| Canada (Excluding Arctic) | 34.0 | 0.25 | 0.5 |
| E-W Germany | 13.1 | 1.00 | 2.0 |
| Great Britain and Ireland | 13.1 | 2.00 | 4.2 |
| Sweden | 12.7 | 0.15 | 0.3 |
| Poland | 8.6 | -- | -- |
| Indonesia | 3.3 | -- | -- |
| Norway | 2.6 | -- | -- |
| All others | 5.2 | 0.4 | 1.2 |
| TOTALS | 408.8 | 100.0 | 214.5 |

## General Comments on Reserve Changes and the Future Role of Economically Marginal Resources

The crude oil reserve estimates shown in Table 6 do not include the most recent upward revision in Mexico. The proven reserves of January 1976, amounting to 6.3 billion barrels have been increased to 20.24 billion barrels as of July 31, 1978. In addition, probable reserves are estimated at an additional 37 billion barrels and potential reserves, including the proven and probable volumes, may be on the order of 200-300 billion barrels. Further exploration and development may place Mexico in the same rank as Saudia Arabia in terms of oil resources.

The oil reserves of mainland China could also be much larger than current estimates based on available information. One recent estimate places proved, probable and possible recoverable reserves at 100 billion barrels. Major exploration and development efforts will be necessary to confirm or amend this figure.

A recent assessment of giant oil fields and world oil resources, not included in the base data used for reporting world oil reserves, has been made by the Rand Corporation[2] for the Central Intelligence Agency. The author concludes that, as of the end of 1975, proved and probable recoverable world crude oil reserves were 676 billion bbl, compared with the 538-606 billion bbl shown in Table 5. However, the Rand figure includes some probable reserves in addition to the generally accepted data for proved and currently recoverable reserves. It is pointed out that the difference between the Rand estimate and those made by other authorities is probably due to a) the definitions of probable reserves used in various estimates, b) the extent to which reserves and recent discoveries are included and c) the differences in various estimates of known total recovery in the Soviet Union. The Rand estimate of ultimate conventional world crude oil resources is in the range of 1,700 - 2,300 billion barrels. If the estimated prior production of 335 billion bbl is subtracted, the total remaining recoverable reserves would be in the range of 1,450 - 1,950 billion bbl, which corresponds very closely to the IGT estimate of 1,500 - 1,840 billion bbl.

A major unknown in estimates of oil reserves is the extent of heavy oil resources which may become exploitable at higher prices. For example, the Orinoco oil sands in Venezuela, with a resource base of 4 trillion barrels, may extend from the eastern slopes of the Andes to Argentina, Bolivia, Peru and Brazil. The resource base for heavy crudes in place in this area may exceed those estimated for Venezuela alone. The extent to which these resources are economically recoverable with current technology is not known, but is probably rather low.

The estimates of world gas reserves presented herein do not include the so-called "non-conventional" sources of natural gas, because such sources cannot be estimated within the framework of the conventional procedures used for reserve evaluation. However, they could become a very important source of future energy supplies as reamining conventional resources decline. In general, such resources are not recoverable under current or near-term economic conditions. The sources are shales of the Mississippian and Devonian age, tight gas formations, coal seams, geopressured aquifers, and gas hydrates. The data base for even preliminary evaluation of these resources is very scanty. However, due to the recent shortage of conventional gas supplies in the United States, these resources are being evaluated by the U.S. government agencies for potential future gas supply. As a result, most of the available data are applicable only to the U.S. situation.

The resource base of gas existing in the Devonian and Mississippian shales in the eastern U.S. is estimated to be on the order of 600 trillion cubic feet. There has been a small amount of production from these shales in the Appalachian area for many years. Major efforts are underway to more rigorously define the resource and to develop means of substantially increasing production rates from wells.

Large areas of gas-containing formations which are relatively impermeable to gas flow exist in the western U.S. (and also in western Canada). The resource base in the U.S. is estimated at 600 trillion cubic feet. Application of advanced fracturing techniques could result in recovery of substantial quantities of this gas.

Many coal seams in the world contain appreciable amounts of natural gas which may be recoverable by specialized drilling and drainage techniques. For the U.S., the resource based of methane associated with coal is estimated at 2,500 trillion cubic feet.

A belt of geopressured aquifers in the gulf coast region of the United States contains brine saturated with natural gas at pressures higher than the hydrostatic head from the surface to the formation. The lack of information on the extent and producibility of the aquifers has resulted in a very wide range for the methane resource estimate - 3,000 to 100,000 trillion cubic feet. Major experimental efforts are underway to more rigorously define the resource base and to devise methods of producing the resource in an economic and environmentally acceptable manner.

The least well-defined and most speculative natural gas resource is gas hydrates. A gas hydrate is a solid compound of methane and related hydrocarbon and water which exists at a relatively low temperature and relatively high pressure. Deposits of gas hydrates have been discovered in Siberia and there is indirect but rather compelling evidence that gas hydrates exist in the North American Arctic regions and in the deep ocean bottom. Some Russian scientists[3] have estimated that the world resource base of submarine gas hydrates is on the order of $1 \times 10^{18}$ cubic meters. To date, no definitive progress has been made in further assessing the extent of this resource or the development of methods for recovery.

Although these unconventional gas resources have been discussed primarily in the context of U.S. experience there is every reason to believe that similar resources exist on a worldwide basis. Of the various sources, the resource base of natural gas associated with coal is probably the most amendable to estimation. Insufficient data are available on the remaining sources although tight sands, shales comparable to the eastern U.S. sources and high pressure zones encountered during oil drilling in other parts of the world lend credence to the belief that similar conditions exist outside the U.S. Only a very small fraction of these resources is producible under current economic conditions. However, as the decline of more conventional supplies of oil and gas forces the price up, the unconventional sources may provide an expanding source of future gas supply.

Another very large potential source of fossil energy is the lower grade oil shales. Recent experimental work by the Institute of Gas Technology has demonstrated that yields of oil from shales of 10-15 gal. oil per ton (by Fischer Assay), using a hydroretorting technique, gives energy recovery equivalent to the conventional retort yield from richer western U.S. shales. The estimated resources in four U.S. eastern states recoverable by above-ground hydroretorting are equivalent to 414 billion bbl oil. A similar resource base is very likely to exist in other parts of the world.

The combined effect of future higher energy prices and advanced technology could permit eventual massive exploitation of non-conventional gas supplies, low grade oil shale, peat, currently unmineable coal deposits and other currently economically marginal or uneconomic fossil energy supplies. In view of the potential size of the resource base, the rationale of doubling the current estimated remaining recoverable resources (Tables 4 and 8) to estimate U.S. and world possible extended fossil fuel resource life seems justified.

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